Wednesday Feb. 23

Syllabus and class notes are at: www.as.utexas.edu
go to courses, AST301 – Introduction to Astronomy – Lacy

Reading for this week: Chapter 8

If you want help on anything covered in the course, come to discussion session Thursday at 6:00 in RLM 15.216B.
Topics for this week

Describe how astronomers measure temperatures of stars.
How do astronomers use parallax to measure the distances to stars? Why does parallax vary inversely with distance?
Describe and explain the relationship between a star’s apparent brightness (or flux), its absolute brightness (or luminosity), and its distance from us.
Describe and explain the relationship between a star’s luminosity, its radius, and its temperature, and how this relationship is used to measure radii of stars.
Sketch an H-R diagram, showing the location of main sequence stars, red giants, and white dwarfs.
Explain how astronomers measure masses of stars.
Describe how the luminosities of main sequence stars are related to their masses.
Spectra of Stars

Hot stars emit more short wavelength light than cooler stars do because atoms in hot stars have more energy than atoms in cooler stars do, so they can emit higher energy photons, which have shorter wavelengths.

The explanation of the pattern of absorption lines is more complicated.

The temperature of a star determines whether an atom is ionized (missing electrons) and what molecules exist.

We can use both the pattern of absorption lines and the shapes of stellar spectra to determine stars’ temperatures. (Hot stars are blue, cool stars are red.)
Parallax and Distance

You judge the distance to objects (depth perception) from the fact that your two eyes view an object from two different locations, so have to look in different directions to look at an object.

The different direction to an object from different positions is called parallax.

Astronomers use the change in the direction to a star during a year, as the Earth orbits around the Sun, to judge the distance to the star.

Nearer stars have bigger parallaxes, or parallax $\alpha = 1 / \text{distance}$.
Stellar parallax

Astronomers use a unit for distance call the parsec (abbreviated pc) so that a star at a distance of 1 pc has a parallax of 1 arcsecond (1/60 of 1/60 of 1°). 1 pc is approximately 3 light-years or 200,000 AU.

What is the parallax of a star with a distance of 2 pc?
A. _ arcsecond
B. 2 arcseconds
C. $10^2$ arcseconds
Stellar parallax

What is the parallax of a star with a distance of 2 pc?
A. _ arcsecond
B. 2 arcseconds
C. $10^2$ arcseconds

Parallax $\alpha \sim 1/\text{distance}$, so if you increase the distance from 1 pc to 2 pc, the parallax decreases by a factor of 2, from 1 arcsecond to _ arcsecond.

$p = 1/d$ if you measure $p$ in arcseconds and $d$ in parsecs.
Another question

What is the distance to a star with a parallax of 0.1 arcseconds?

A. 0.1 pc
B. 1 pc
C. 10 pc
Another question

What is the distance to a star with a parallax of 0.1 arcseconds?

A. 0.1 pc
B. 1 pc
C. 10 pc

\[ d(pc) = \frac{1}{p(arc\ sec)} = \frac{1}{0.1} = \frac{1}{\left(\frac{1}{10}\right)} = 10 \]
Apparent brightness

How bright a star appears is determined by how much light from that star enters your eye.

That is given by the product of the area of your pupil and the light power per unit area reaching you from the star.

We refer to the power per unit area as the flux or apparent brightness of the star.

Flux = Power / Area

You can calculate the flux of light from a star by dividing the power emitted by the star by the area it has spread over by the time it gets to you.

Because all areas vary as the square of the size of the object, the area the light has spread over varies as the square of the distance it has traveled.
Flux or Apparent Brightness

In traveling a distance of 1 pc from a star, light spreads out over some area.

When the light has traveled a distance of 2 pc from the star, it has spread out over 4 times as much area.

Since the flux of starlight is the power emitted divided by the area it has spread over, the flux is 4 times smaller 2 pc from the star than it is at 1 pc.

The formula is: \( \text{Flux} \propto \frac{1}{\text{distance}^2} \)

Or if the stars we are comparing have different luminosities (power emitted), the formula becomes:

\( \text{Flux} \propto \frac{\text{Luminosity}}{\text{distance}^2} \)
Quiz

Sirius and Vega are very similar stars. They emit about the same amount of light power. But Vega is about 3 times farther from us than Sirius is.

Which star appears brighter?
A. Sirius
B. Vega

How many times brighter?
A. 3
B. 6
C. 9
Quiz

Sirius and Vega are very similar stars. They emit about the same amount of light power. But Vega is about 3 times farther from us than Sirius is.

Which star appears brighter?
A. Sirius  It is closer to us.
B. Vega

How many times brighter?
A. 3
B. 6
C. 9  Tripling the distance multiplies the area the light is spread over by $3^2 = 9$ times.
Combine parallax and brightness

Spica and Canopus emit about the same amount of power. Spica has a parallax of .005 arcsec and Canopus has a parallax of .01 arcsec.

How do Spica and Canopus compare in apparent brightness?

Work it out and compare answers with your neighbors.
Combine parallax and brightness

Canopus has twice the parallax of Spica. Since distance $\alpha \propto 1 / \text{parallax}$, Spica must be at twice the distance of Canopus. (The numbers are 100 pc and 200 pc, but you don’t need to know that.) The more distant star (Spica) appears fainter. Since it is twice as distant as Canopus, it appears 4 times fainter, or _ as bright.
Absolute Magnitude

We won’t use absolute magnitude much, but you should know that it is a way of expressing the amount of light a star puts out (rather than the amount that hits your eye).

Like the apparent magnitude system, each increase of one magnitude means a decrease in light by a factor of 2.5. The Sun has an absolute magnitude of about 5. A star with an absolute magnitude of 6 emits about 2.5 times less light than the Sun does. A star with an absolute magnitude of 0 (that’s 5 magnitudes smaller than the Sun) emits about $2.5 \times 2.5 \times 2.5 \times 2.5 \times 2.5$ (or 100) times as much light as the Sun.

Remember: smaller magnitudes mean more light.